MULTIMEDIA UNIVERSITY

STUDENT ID NO

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# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

**TRIMESTER 1, 2019/2020**

## EEN3096 – COMMUNICATION ELECTRONICS

( TE / RE )

18 OCTOBER 2019
3.00 p.m - 5.00 p.m
( 2 Hours )

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**INSTRUCTIONS TO STUDENT**

1. This Question paper consists of 6 pages excluding cover page with 4 Questions only.

2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Fig. Q1a shows a system of cascaded attenuators. The total attenuation is 20 dB.

(i) Determine the value of resistors $R_1$, $R_2$, $R_3$, and $R_4$. [12 marks]

(ii) Calculate $V_{out}$. [2 marks]

(iii) What does it means by 20dB attenuation? How would the system be affected with increasing attenuation? [1 + 1 marks]

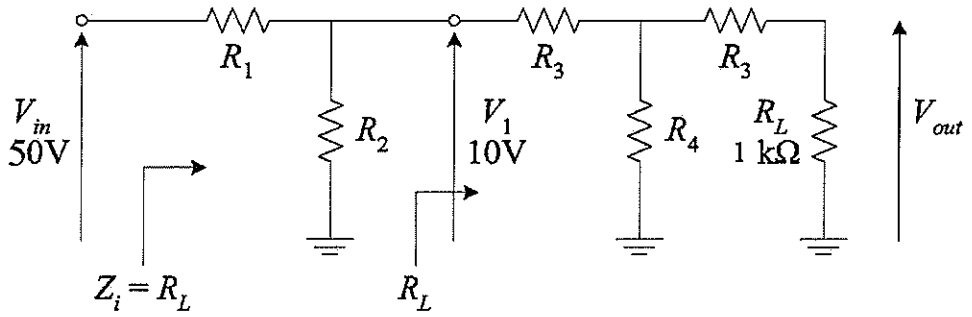


**Fig. Q1a**

(b) (i) Define the term "Quality Factor" in electronic circuits. [2 marks]

(ii) Compare a circuit with smaller "Quality factor" to a circuit with larger "Quality factor" in terms of its energy stored and loss.

[2 marks]

(c) Determine the quality factor (Q) and the half-power bandwidth (BW) of the $\pi$-impedance matching network in Fig. Q1b below, given that $f_o$ = 1 MHz and $R_l = R_s/2$ = 50 ohms. [3 + 2 marks]

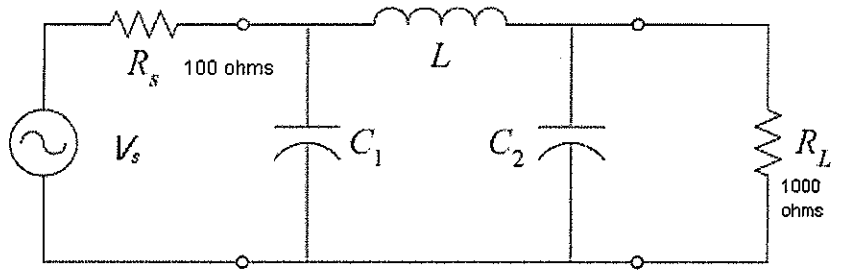


**Fig. Q1b** **Continued .....**

Question 2

Fig. Q2 shows the circuit diagram for a class A untuned amplifier using a 2N3904 npn-BJT as the active device. It is given that the transistor has the following parameters: $r_{bb'}$=25Ω, $h_{fe}$=200, $V_{BE}$=0.7V, $V_A$=40V, $C_C$=5pF and $f_T$ = 300MHz at T = 300K.

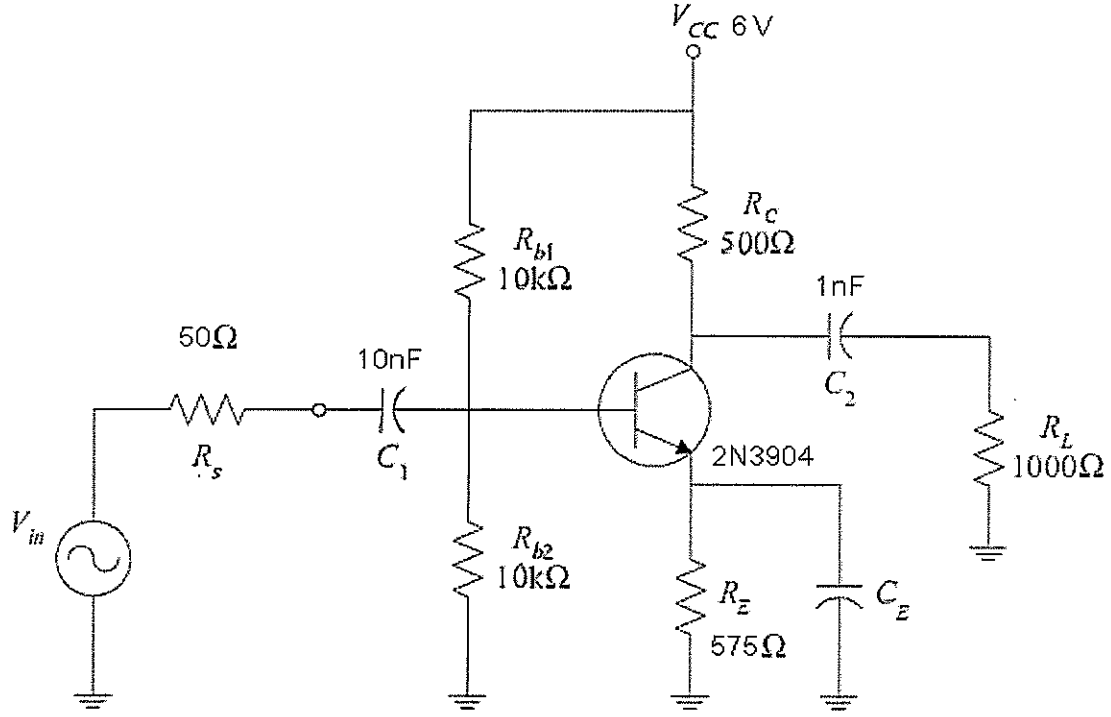


Fig. Q2

(a) With the aid of a revised circuit diagram, show how the untuned amplifier circuit can be converted into a tuned amplifier circuit by the incorporation of an inductor of L = 0.22$\mu$H and a capacitor $C$. [2 marks]

(b) Applying the hybrid-$\pi$ model and the Miller's approximation to the tuned amplifier circuit in (a), which is set to operate at a frequency $f_o$ = 50 MHz and biased at $I_C$ = 4mA,

(i) determine the values of the capacitor $C$ and $C_e$, [6 marks]
(ii) determine the effective voltage gain of the amplifier in dB [10 marks]
(iii) determine the bandwidth of the amplifier [4 marks]

(c) List out THREE (3) advantages of the Tuned Amplifiers. [3 marks]

**Continued .....**

Question 3

(a) Name FOUR (4) applications of Phase Locked Loop (PLL). [4 marks]

(b) Discuss the three modes of phase locked loop operation. [6 marks]

(c) For a PLL circuit as shown in Fig. Q3, the VCO has a free running frequency, $f_{FR}$ = 2MHz, an external input frequency $f_i$ = 2.1MHz and the transfer function $k_\phi$ = 0.1 V/rad, $k_A$ = 4.7, $k_o$ = 0.2MHz/V. Determine the following:

(i) PLL open loop gain in Hz/rad ($k_L$), rad/second ($k_v$) and $k_v$ in dB. [5 marks]
(ii) Change of the VCO frequency necessary to achieve lock ($\Delta f$). [2 marks]
(iii) PLL output voltage ($V_o$). [2 marks]
(iv) Phase detector output voltage ($V_d$). [2 marks]
(v) Static phase error ($\theta_e$). [2 marks]
(vi) Hold-in range ($\Delta f_H$). [2 marks]

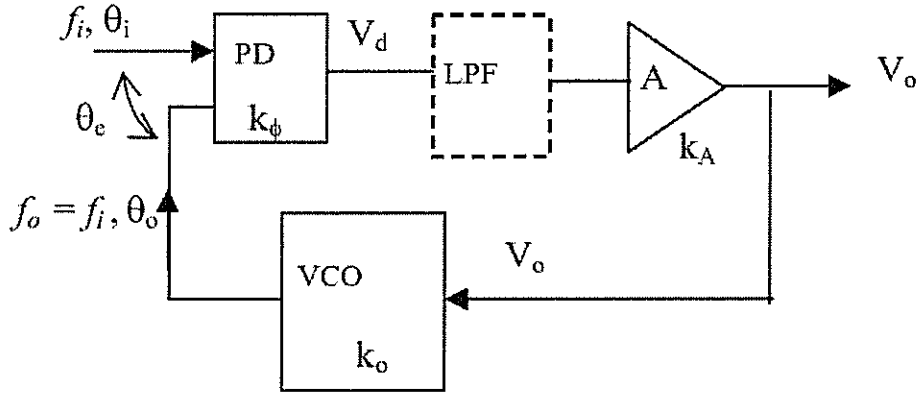


Fig. Q3

**Continued .....**

Question 4

(a) Compare the characteristic of the coherent detector and non-coherent detector. State an example for each of them. [4 + 2 marks]

(b) A transmitter transmits an AM signal with a carrier frequency of 1500kHz. When an inexpensive radio receiver (which has a poor selectivity in its RF stage band-pass filter) is tuned to 1500 kHz, the signal is heard loud and clear. The same signal is also heard (not as strong) at another dial setting. The intermediate frequency (IF) is 455 kHz. Justify, with reasons, at what frequency this station can be heard?

[10 marks]

(c) An AM broadcast receiver tunes from 500kHz to 1800kHz. The intermediate frequency IF is 455kHz and the local oscillator uses high-side injection (high tracking). The local oscillator uses a variable capacitor with a maximum value of 400pF. Calculate the following:

(i) The range of frequencies that must be generated by the local oscillator and the respective image frequencies.

[6 marks]

(ii) The value of inductor needed so that the local oscillator will tune the receiver to the lowest frequency on the band when the capacitor is at maximum.

[3 marks]

**Continued .....**

Appendix – Useful Formulas

## 1. L impedance matching network (when $R_L > R_S$):

$$B = \frac{X_L \pm \sqrt{R_L / R_s}\sqrt{R_L^{\,2} + X_L^{\,2} - R_s R_L}}{R_L^{\,2} + X_L^{\,2}} \qquad X = \frac{1}{B} + \frac{X_L R_s}{R_L} - \frac{R_s}{B R_L}$$

$$Q = \frac{|X|}{R_S}$$

## 2. L impedance matching network (when $R_L < R_S$):

$$B = \pm\frac{\sqrt{(R_s - R_L)/R_L}}{R_s} \qquad X = \pm\sqrt{R_L(R_s - R_L)} - X_L \qquad Q = R_S|B|$$

## 3. π impedance matching network:

$$L = L_1 + L_2 = \frac{R_L}{\omega_o}\left(\sqrt{R_S / R_I - 1} + \sqrt{R_L / R_I - 1}\right)$$

$$C_1 = \frac{1}{\omega_o R_S}\sqrt{\frac{R_S}{R_I} - 1} \qquad C_2 = \frac{1}{\omega_o R_L}\sqrt{\frac{R_L}{R_I} - 1} \qquad Q = \sqrt{\frac{R_S}{R_I} - 1} + \sqrt{\frac{R_L}{R_I} - 1}$$

## 4. RF Class A transistor amplifier (Hybrid π model of BJT)

| | |
|---|---|
| $r_{bb'}$ | **The base-spreading resistance.** |
| $g_m$ | **The transconductance.** $g_m = \frac{dI_C}{dV_{BE}} = \frac{qI_C}{kT} \cong \frac{I_C(\text{in mA})}{25.875mV}$ at T=300K, q= electronic charge, $1.6\text{x}10^{-19}$C |
| $C_e$ | **The emitter capacitance.** |
| $r_{b'e}$ | **The input resistance.** $r_{b'e} = \frac{dV_{B'E}}{dI_B} = \frac{h_{fe}}{g_m}$ |
| $r_{b'c}$ | **The collector to base resistance.** $r_{b'c} = h_{fe} r_{ce}$ |
| $C_C$ | **The collector capacitance.** |
| $r_{ce}$ | **The output resistance.** $r_{ce} \cong \frac{V_A}{I_C} = \frac{qV_A}{kTg_m}$ Where $V_A$ is known as the Early voltage and $I_C$ is the dc collector current. |

**Continued .....**

## 5. High frequency Class A amplifier parameters:

### (a) Voltage gain:

$$A_V = \frac{v_o}{v_{BE}} = -g_m R_o \frac{r_{b'e}}{r_{bb'} + r_{b'e}} \frac{1}{1 + j\omega C_T \dfrac{r_{bb'} r_{b'e}}{r_{bb'} + r_{b'e}}}$$

In cases where $r_{bb'} << r_{b'e}$ then

$$A_V = \frac{v_o}{v_{BE}} = -\frac{g_m R_o}{1 + j\omega C_T r_{bb'}}$$

### (b) Effective voltage gain (including the effect of source impedance Rs):

$$A_{VS} = \frac{v_o}{V_S} = -g_m R_o \frac{r_{b'e}}{r_{bb'} + R_S + r_{b'e}} \frac{1}{1 + j\omega C_T \dfrac{(R_S + r_{bb'}) r_{b'e}}{R_S + r_{bb'} + r_{b'e}}}$$

In cases where $(R_s + r_{bb'}) << r_{b'e}$ then

$$A_{VS} = \frac{v_o}{V_S} = -\frac{g_m R_o}{1 + j\omega C_T (R_S + r_{bb'})}$$

Where $C_T = C_e + C_M$ and $C_M$ = Miller capacitance $C_M = (1 + g_m R_o) C_C$

### (c) Transition frequency

$$f_T = \frac{1}{2\pi} \frac{g_m}{C_e + C_C}$$

### (d) Input impedance

$$Z_I = r_{bb'} + \frac{r_{b'e}}{1 + j\omega r_{b'e} C_T}$$

**End of Paper**